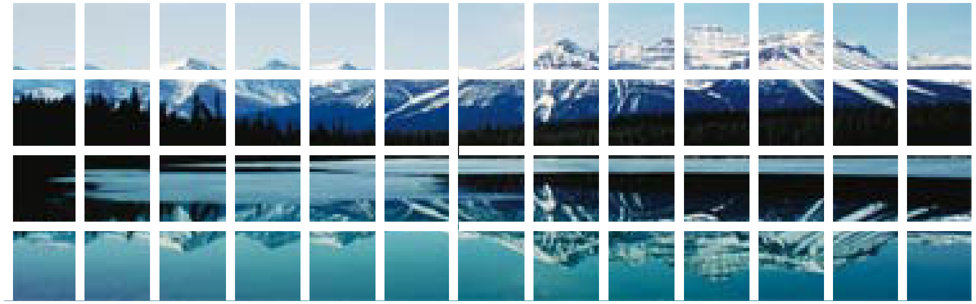
Ballard Power Systems



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Development, Characterization and Evaluation of Transition Metal/ Chalcogen Based Cathode Catalysts for PEM Fuel Cells

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Ballard Power Systems

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Project Overview/Objectives

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- To develop a non-precious metal cathode catalyst for PEM fuel cells which is as active and as durable as current PGM based catalysts at a significantly reduced cost.
  - Development of composition and structure
  - Process development (can be scaled up)
  - Evaluation/ demonstration in fuel cells & stacks.

Budget

Project year	Federal	Applicant	Total
1	$549,267	$200,300	$749,567
2	$529,280	$82,320	$611,600
3	$491,206	$122,802	$614,008
Total	$1,580,139	$395,036	$1,975,175

Funding in FY04 is $400,000 from DOE

and $100,000 from Ballard (20%)

Technical Barriers and Targets

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- DOE Technical Barriers for Fuel Cell Components
  - O. Stack Material and Manufacturing Cost
  - P. Durability

- DOE Technical Target for Fuel Cell Stack System for 2010
  - Cost 35 to 45 \$ kW_e^{-1} depending upon platform
  - Durability 5000 hours (including thermal and realistic drive cycles)

Technical Approach

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- To determine the optimum catalyst composition (metal,chalcogen) and structure using well-defined, thin film materials on glassy carbon.
  - Determine best metal, best chalcogen and ratio
  - Determine best structure/ phase of that composition
- To duplicate this structure as well as possible on carbon black using manufacturable processes.
  - Develop aqueous/ thermal process to produce similar structure/ composition at high dispersion on a conductive carbon support
- To optimize the electrode structure in a fuel cell and demonstrate performance and durability.
  - Optimize catalyst loading and Nafion/ catalyst structure in electrode.

Safety Slide

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- Work done at UBC uses established laboratory equipment and practices.
- Care is exercised when handling the selenium targets but these will remain enclosed in the vacuum system of the coater.
- Standard safe laboratory practices and procedures are followed.
- In the final phase the catalyst will be tested at Ballard in fuel cells.
- This will be carried out in systems which have undergone rigorous HAZOP during design,build and maintenance.
- This is the only part of the project that will use hydrogen gas.

Project timeline

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Phase 1	Phase 2	Phase 3
2/04 - 6/05	6/05 - 6/06	7/06 – 6/07

- Phase 1 – Ex-situ thin film matrix
  1. Rough screening using Co, Fe, Cr with Se, S
  2. Detailed optimization of composition and structure
  3. Down-selection of preferred catalyst
- Phase 2 – Development of process for manufacture of dispersed catalyst structures.
  4. Develop aqueous/ thermal process to make dispersed catalyst.
  5. HRTEM characterization with RDE and XPS
  6. Delivery of catalyst to Ballard for fuel cell testing
- Phase 3 – Fuel cell testing
  7. Optimize catalyst structure (loading, Nafion content, etc)
  8. Performance and stability assessment
  9. Deliver stack for independent evaluation and return.

Technical Accomplishment Summary

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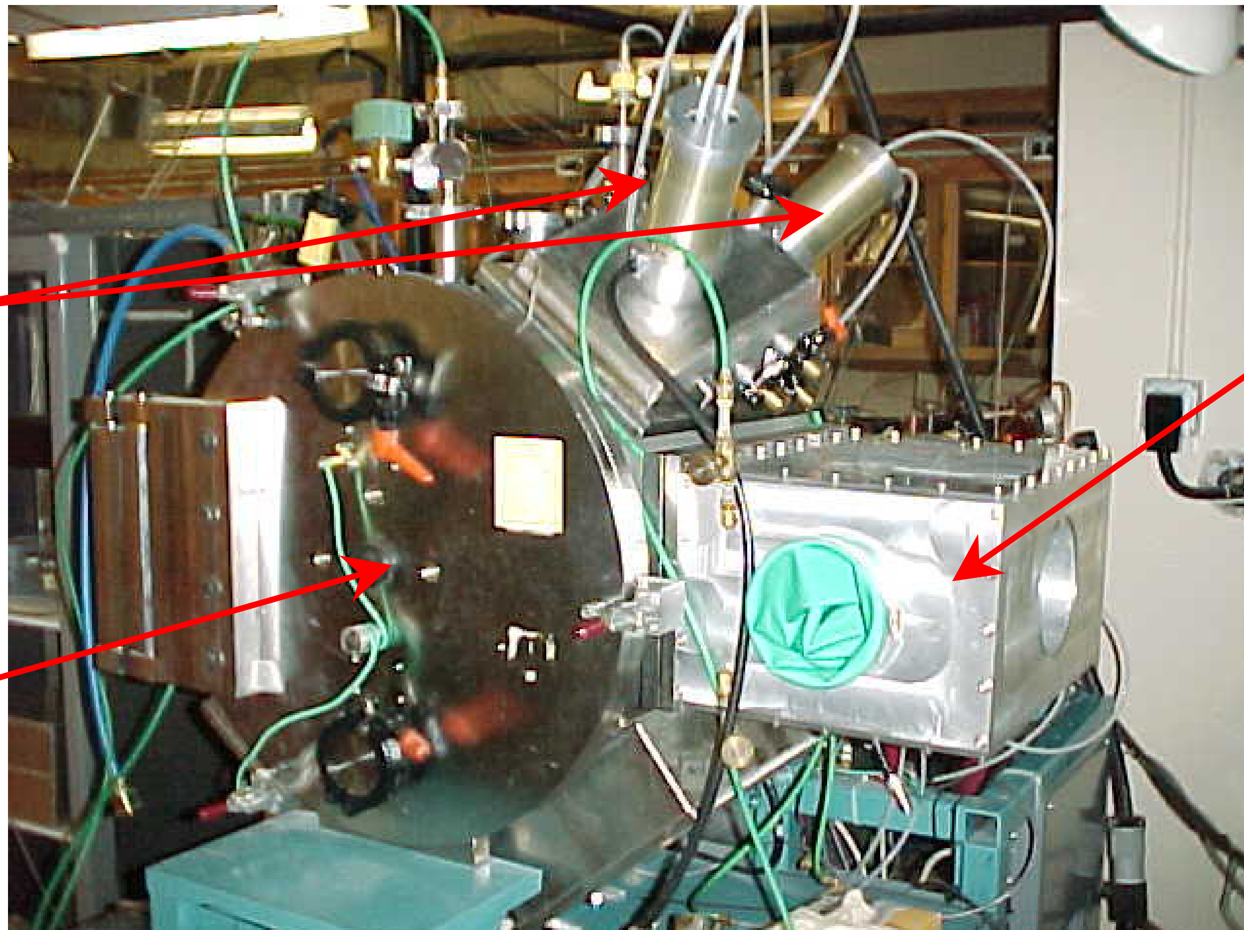
- Research staff (post-doctoral fellows and graduate students) are in place and working.
- Glassy carbon substrate has been machined into discs to fit the rotating electrode holder
- Initial baselines using sputtered platinum to be obtained in early April. Data to follow
- Coater modifications completed.
- It is expected to be coating Co_xSe_y thin films by mid-April. Data to follow

Technical Accomplishment Summary

Two source magnetron sputtering chamber to deposit thin films



Interactions and Collaborations

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- University of British Columbia:-
  - Prof. Bob Parsons; thin film deposition, sputter coating (phase I)
  - Prof. Keith Mitchell; surface science analysis (XPS, Auger, XRD) (phase I)
  - Prof. Dan Bizzotto; electrochemical characterisation (phases I & II)

- Case Western Reserve University:-
  - Prof. Frank Ernst; High resolution transmission electron microscopy (HRTEM) for characterisation of powder catalyst in phase II.

Future Work

- For FY 2004
  - Develop compositional screening matrix using Co, Cr, Fe and Se.
  - Down-select composition with best activity/ stability.
  - Fully characterize the structure of the down-selected composition.

- FY 2005-2006
  - Add sulfur to the screening matrix and determine if better than Se.
  - Develop process to make dispersed catalytic material supported on carbon.
  - Determine that powder catalyst has similar composition and structure to thin film.
  - Deliver down-selected catalyst composition as powder for in-situ fuel cell optimization

Future Work

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- FY 2007
  - In-situ fuel cell optimisation of down-selected powder catalyst.
    - Catalyst loading to meet cost/ performance targets.
    - Optimize catalyst/ ionomer structure for performance and stability.
    - Manufacture cathodes for Mk513 short stack and build stack.
    - Performance and lifetime test to validate catalyst.
    - Deliver stack for independent evaluation.